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Ergonomic Analysis of a Firearm According to the Anthropometric Dimension

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Abstract

The paper summarizes the results of an ergonomic analysis of firearms with regard to anthropometric dimensions of selected populations. For evaluation 3D digital human models, which represent currently the best technology, have been used. Analyses are performed for three major population groups (Americans, Europeans and Asians). Ranges to controls (e.g. lock, trigger, etc.) are critically evaluated. The grip of the firearm according to the position of shooters wrist is also a subject to critical analysis. At the end of the paper the deficiencies found are discussed as well as a bad situation regarding the availability and timeliness of anthropometric dimensions of Czech population. Further work that is described will be focused on the creation of national anthropometric database. The database shall include the dimensions of the hand and will be created according to the rules of EN ISO 15535. The data will be suitable for the design of other hand tools from various sectors.

1. Introduction

Ergonomics as a multidisciplinary science extends to many fields of human activities. In the last years the division stabilized on product and process ergonomics. Product ergonomics primarily focuses on the product and how this product should comply specific parameters of friendliness to human. Process ergonomics is focuses by contrast on production method of product. This process should be design regard to human demands. This article is mainly focuses on the field of product ergonomics. The subject of our study is relatively unusual product, which is a

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firearm. Mainly armed forces (army, police, etc.) come into contact with guns nearly every day. For this reason these weapons must be adapted to fit in the hand in the best way. Thus the weapons must be maximally reliable during shooting.

Creation of universal product which would fit to all users on global market is absolutely impossible. The aim must always be to ensure friendliness for the largest possible group. The differences between various populations throughout the world are significant if we compare statures of Asians and Europeans or Americans. It is important to use anthropometric databases to design concrete product. These databases allow usage of the physical dimensions of different populations so that the final product can be tailored to certain group of users.

Today the information technologies are perceived as an indispensable tool in the design of a new product. Possibility to verify product parameters and suitability for user in computer virtual reality before functional prototype is absolutely undeniable. For this purpose the digital human models (DHM) are used. These DHM are fully customizable, so that results of studies carried out are perhaps the most realistic. If we talk about customization of a DHM, we mean setting its gender, nationality, percentile or specific body measurements, so that our digital human as much as possible corresponds to specific user. With user defined like this we then have the possibility to perform a variety of ergonomic analysis. We can find out how users (from different population size) will perform a given task, analyze the risk of injury, needed power, reach, grips and many other factors.

2. Methodology

For analysis and development of new weapons within Czech Republic we used the ergonomic software Tecnomatix Jack and digital human model included in this software ranks among the best in its category[1]. Tecnomatix Jack (Tx Jack) contains several anthropometric databases and it is possible to compare weapon models for different populations. Based on these results we can say, what suits and what is appropriate to change.

Ergonomic analysis of firearms related mainly to the suitability of the location of the controls and the way of the weapon grip. The aim was to ensure maximum comfort during weapon using and also elimination of adverse effects on the user which related to safety use. Each weapon should be suitable for the widest number of users. Therefore three populations were chosen for analysis. It is database ANSUR ANSUR [2] (U.S. Army Anthropometry Survey) which represents American population, GERMAN [3] which represents European population and KOREAN [4] which represents Asian population. For each population analyses were carried out for three different sizes of statures, namely for 5th, 50th and 95th percentile.

The first step was to compare available anthropometric databases and databases contained in Tx Jack (Table 1, Table 2 and Table 3). The tables show the comparison only for men, but the comparison and subsequent analysis were conducted also for women, which was one of the requirements of the assignment. Within this comparison we verified that the database differences are minimal and therefore it is possible to fully utilized software Tx Jack for subsequent analyses. The largest deviation in compared dimensions amounted to 6 mm in length of hand for 95th percentile of Korean population. Generally, it can be argued that in fact the majority of dimensions for the 95th percentile greatest differences were achieved.

Table 1. Comparison of hand anthropometry according to Hand Anthropometry of U.S. Army Personnel [2] and ANSUR Population Tx Jack.

MEN	Percentile	Hand Anthropometry of U.S. Army Personnel	ANSUR Population Tx Jack
Hand length [cm]	5	17,85	18,3
	50	19,35	19,3
	95	21,09	20,6
Hand breadth [cm]	5	8,36	8,6
	50	9,02	9,1
	95	9,76	9,5

Table 2. Comparison of hand anthropometry according to DIN 33402-2 [3] anf GERMAN Population Tx Jack.

MEN	Percentile	DIN 33402-2	GERMAN Population Tx Jack